Mediterranean diet and mortality in Switzerland: an alpine paradox?

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Abstract: PURPOSE: Reports on the protective effect of a Mediterranean diet on mortality usually refer to populations from Mediterranean countries, leaving uncertain whether really diet is the fundamental cause. Our aim was to examine the effect of a Mediterranean diet on mortality in Switzerland, a country combining cultural influences from Mediterranean and Central European countries within a common national health and statistical registry. METHODS: In this prospective investigation, we included 17,861 men and women aged 16 years who participated 1977-1993 in health studies and were followed up for survival until 2008 by anonymous record linkage with the Swiss National Cohort. A 9-point score Mediterranean Diet Score (MDS) was used to assess adherence to a Mediterranean diet. Mortality hazard ratios (HR) and 95 % confidence intervals (CIs) were calculated by using Cox regression models adjusted for age, sex, survey wave, marital status, smoking, body mass index, language region and nationality. RESULTS: In all language regions, MDS was inversely associated with mortality. Consumption of dairy products was also consistently associated with lower mortality. When categorizing dairy food consumption as beneficial instead of harmful, this association between MDS and mortality increased in strength and was partly statistically significant. For all causes of death combined (HR for a one-point increase in MDS 0.96, 95 % CI 0.94-0.98), in men (0.94, 0.92-0.97), in women (0.98, 0.95-1.02) for cardiovascular diseases (CVD, 0.96, 0.92-0.99; 0.95, 0.90-1.00; 0.98, 0.92-1.04) and for cancer (0.95, 0.92-0.99; 0.92, 0.88-0.97; 0.98, 0.93-1.04). CONCLUSIONS: Stronger adherence to a Mediterranean diet was associated with lower all-cause, CVD and cancer mortality, largely independently of cultural background. These associations were primary due to the effect in men. Our finding of a beneficial rather than a deleterious impact of dairy products consumption prompts at considering culturally adapted Mediterranean diet recommendations. However, results should be interpreted with caution since only a crude 1-day dietary estimate was available to assess individuals' habitual dietary intake.

DOI: https://doi.org/10.1007/s00394-014-0695-y

Eur J Nutr (2015) 54:139–148
DOI 10.1007/s00394-014-0695-y

ORIGINAL CONTRIBUTION

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Received: 13 October 2013 / Accepted: 27 March 2014 / Published online: 8 April 2014

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Methods In this prospective investigation, we included 17,861 men and women aged ≥16 years who participated 1977–1993 in health studies and were followed up for survival until 2008 by anonymous record linkage with the Swiss National Cohort. A 9-point score Mediterranean Diet Score (MDS) was used to assess adherence to a Mediterranean diet. Mortality hazard ratios (HR) and 95 % confidence intervals (CIs) were calculated by using Cox regression models adjusted for age, sex, survey wave, marital status, smoking, body mass index, language region and nationality.
Results In all language regions, MDS was inversely associated with mortality. Consumption of dairy products was also consistently associated with lower mortality. When categorizing dairy food consumption as beneficial instead of harmful, this association between MDS and mortality increased in strength and was partly statistically significant. For all causes of death combined (HR for a one-point increase in MDS 0.96, 95 % CI 0.94–0.98), in men (0.94, 0.92–0.97), in women (0.98, 0.95–1.02) for cardiovascular diseases (CVD, 0.96, 0.92–0.99; 0.95, 0.90–1.00; 0.98, 0.92–1.04) and for cancer (0.95, 0.92–0.99; 0.92, 0.88–0.97; 0.98, 0.93–1.04).
Conclusions Stronger adherence to a Mediterranean diet was associated with lower all-cause, CVD and cancer mortality, largely independently of cultural background. These associations were primary due to the effect in men. Our finding of a beneficial rather than a deleterious impact of dairy products consumption prompts at considering culturally adapted Mediterranean diet recommendations. However, results should be interpreted with caution since only a crude 1-day dietary estimate was available to assess individuals' habitual dietary intake.

Keywords Mediterranean diet · Alpine paradox · Dairy food · Mortality · Switzerland

Abbreviations

BMI	Body mass index
CI	Confidence interval
CVD	Cardiovascular disease
HR	Hazard ratio
ICD	International Classification of Diseases
MDS	Mediterranean Diet Score
MONICA	MONItoring of trends and determinants in CArdiovscular disease

For the Swiss National Cohort Study Group.

Electronic supplementary material The online version of this article (doi:10.1007/s00394-014-0695-y) contains supplementary material, which is available to authorized users.

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NRP 1A	National Research Programm 1A
SNC	Swiss National Cohort
WHO	World Health Organization

Introduction

Adherence to a Mediterranean diet was associated with lower risk of chronic diseases such as cardiovascular and neurodegenerative diseases and cancer [1–16]. This diet is characterized by a high intake of vegetables, fruits, legumes, complex carbohydrates, unsaturated lipids (mainly olive oil), a moderate consumption of fish and alcohol (mainly in form of wine with the meals) and a low intake of dairy products and meat [13, 14, 17].

This construct allows for identifying individuals or populations having high- and poor-quality diets. However, the impact of a Mediterranean diet on health may depend on cultural background. In fact, the impact appears to be more beneficial in populations living in Mediterranean countries than in those of more western and northern European countries [7, 18], leaving uncertain whether diet is indeed the fundamental cause. However, comparisons between countries are susceptible to bias due to national variations in collecting, processing and interpretating data and in assignment of causes of death. Switzerland offers a unique setting for the investigation of the "pure" impact of culture on mortality because it combines cultural diversity with a common national health and statistical registry. This country has three main language regions, each of them having characteristic cultures in many respects similar to those found in Germany, France and Italy. Another characteristic of Switzerland is the generally high consumption and the high quality of milk and dairy products [19, 20].

We aimed to determine the association of adherence to a Mediterranean diet with all-cause, cardiovascular disease (CVD) and cancer mortality, taking into account the particular features of Switzerland. For this purpose, we investigated samples of the population from all three language regions who participated in health surveys and for whom mortality follow-up of up to over 30 years is available.

Subjects and methods

Study population

This study is based on pooled data from two cross-sectional studies conducted in Switzerland: (1) The National Research Program 1A (NRP 1A), a community health promotion initiative focused on cardiovascular disease prevention which has been conducted between 1977 and 1979. A random sample of 4,386 participants was recruited and 4,245 additional persons participated spontaneously. Age at baseline ranged 16–92 years [21]. (2) The Swiss MONItoring of trends and determinants in CArdiovascular disease (MONICA) study, an international project of the World Health Organization (WHO). The study was conducted in three waves (data collection phases) between 1983 and 1992 in men and women aged 25–74. Of the initially sampled persons, between 54 and 78 % participated in the study [22, 23]. Baseline data of the 17,861 participants, of whom 3,953 died during the follow-up period of up to 32 years (mean: 21.4 years), were collected between 1977 and 1993. Mortality follow-up information is available thanks to anonymous record linkage with the Swiss National Cohort (SNC) [23–25]. Loss to follow-up was 3.4 %.

Record linkage procedure

In order to determine vital status, anonymous record linkage of MONICA and NRP 1A participants with the SNC was conducted, providing also information about cause of death. The SNC encompasses all residents of Switzerland included in the national censuses of 1990 and 2000 (6.8 and 7.3 million, respectively). The record linkage procedures included all potential identification variables, i.e. variables available in the two cross-sectional studies and in the SNC. Sex, exact date of birth and place of residence were the minimal requirements for a promising record linkage. Additional helpful identification variables were nationality, marital status, educational status and profession [23–25]. Finally, in order to increase the power of the study, the separately linked MONICA and NRP 1A datasets were pooled.

Exposure variables

Data on diet

Consumption of food groups was assessed by the standardized protocols used in NRP 1A [21] and the Swiss MONICA study [22]. Participants of these studies attended a health examination in their community of residence and completed a self-administered questionnaire. The dietary assessment method used was a simplified 24-h recall checklist that consisted of simple yes/no questions about food and beverage intake on the previous day. Eleven different food groups were considered: salad, fruits, vegetables, dairy products, grains, meat, fish, type of oils/fats, alcohol, eggs, chocolate (also see Online Resource Table S2). The questions in the questionnaire differentiated whether the food has been consumed in solid or liquid

form. For each question, multiple answers were possible. As no weight units (g) or portion size were assessed in the self-administered questionnaire, no median value could be calculated for a more detailed classification, and we had to consider for each item the answer "yes" as being part of the participants daily diet and the answer "no" as the opposite. As a sensitivity analysis, we included the answer to the questions "was yesterday a weekday?" and "was yesterday a normal or an unusual day regarding your diet?" as covariates in our analyses in order to consider the "representativeness" of the day for which dietary intake was reported. Doing so, however, did not affect the exposure-mortality association. Therefore, we decided not to include these variables in our analyses.

Mediterranean Diet Score (MDS)

To assess the degree of adherence to a Mediterranean diet, a 9-point score in analogy to that developed by Trichopoulou et al. [26] was used. Such an approach can provide a valid assessment of dietary patterns [27]. The MDS in our analysis comprised of 9 distinct components: salad, vegetables, fruits, dairy products, whole grains, meat, fish, monounsaturated lipids and alcohol (wine). For each component, a value of 0, 1 or 0.5 (the latter in case of monounsaturated lipids) was assigned. Individuals preferring a "beneficial" component (salad, vegetables, fruits, whole grains, white meat, fish, monounsaturated lipids, alcohol) or avoided a "detrimental" (red or processed meat) component were assigned a value of 1 (see also Online Resource Table S1 and S2). In contrast to most other studies on Mediterranean diet, we clearly found a beneficial effect of consuming dairy products. Thus, at odds with the traditional concept, we also assigned a value of 1 for the consumption of dairy products. Our modified MDS ranged from 0 (minimal adherence) to 9 (maximal adherence). The MDS applied in this study differs in some respect from the diet score used by Trichopoulou et al. [26]: Fruit and nuts were not combined because we had insufficient information on nut consumption; for the same reason, legumes are not part of the score; only whole grains are included instead of cereal products in general; use of the same alcohol range for both men and women; no further classification according to a median because of the absence of data regarding weight units (g) of the daily intake of the components. The MDS was divided into three groups: 0 to <4 ($n = 4{,}042$), 4 to <6 ($n = 9{,}418$) and 6–9 ($n = 4{,}340$) (see also Online Resource Table S3).

Cultural background

For analyses of the association between the cultural background and the Mediterranean diet patterns, participants were classified into four categories related to language and nationality: German-, French- and Italian-speaking Swiss nationals, nationals from other countries (France, Germany, Italy, Spain, Great Britain, Austria, other). Swiss nationals were categorized by native language or place of residence.

Covariates

From the available variables, we used sociodemographic parameters (sex; age; marital status: never married, married, widowed, divorced), anthropometric measurements (body mass index, BMI, calculated from measured height and weight), health-related habits (smoking status: never, former, light, heavy) and survey (wave: NRP 1A; MONICA I, II, III).

Outcome variables

Causes of death were classified according to the International Classification of Diseases (ICD) revisions 8 (ICD-8) and 10 (ICD-10). In Switzerland, ICD-8 was used until 1994, followed by ICD-10 thereafter. Causes of death were grouped into CVD (ICD-8: 390–458; ICD-10: I00–I99) and cancer (ICD-8: 140–239; ICD-10: C00–C99; D00–D48).

Statistical analyses

We calculated counts, means and proportions for all variables of interest. Mortality rates by sex were age-standardized with the direct method to the WHO's "European" standard age structure [28]. We calculated hazard ratios (HR), 95 % confidence intervals (CIs) and p values using Cox proportional hazard regression models. The Cox models were used to assess the association of the MDS and the studied food groups with all-cause, CVD and cancer mortality. All models were calculated separately for men and women, adjusted with an increasing number of covariates. In model 1 (basic model), we adjusted for age and study (wave); in model 2 (full model) additionally for marital status, smoking status, BMI, region and nationality. Selection of covariates was based on Akaike's information criterion (AIC) and the Bayesian information criterion (BIC). Separate analyses were conducted in order to analyse the impact of nationality and region on the MDS. The proportional hazards assumption was tested and was not fulfilled for the joint models, but fulfilled for almost all sex-specific models. Analyses were conducted with STATA version 11.2 (Stata Corporation, College Station, TX, USA), and $p < 0.05$ was considered to be statistically significant (two-sided tests).

Results

Table 1 shows baseline characteristics of the study population by sex. The number of participants who died from CVD and cancer was similar among men and women, respectively. Smoking and overweight/obesity were quite common, particularly among men. Most participants were of Swiss nationality and about every second participant lived in the French-speaking part of Switzerland. Consumption of food groups was similar among sexes with the exception of fruit consumption being more frequent in women and alcohol consumption being more frequent in men (for details, see Online Resource Table S1, S4 and S5).

Results from Cox regression models for selected food groups are presented in Table 2. The models for each single food group (HR) were adjusted for possible confounders and, in addition, mutually, i.e. for all remaining food groups. Individuals having consumed fruits the previous day had lower risks of dying from CVD and cancer mortality than those who did not. An inverse association between monounsaturated fat consumption and CVD mortality was only seen in men. For alcohol, opposite effects were observed regarding CVD (lower) and cancer (higher) mortality. Consumption of no meat or only white meat showed almost no significant effect except for women, in whom it was inversely associated with cancer mortality. In both men and women, consumption of diary products showed an inverse association with CVD and cancer mortality.

Table 3 shows HRs for a one-point increase in MDS of Cox regression models comparing the traditional continuous MDS (ranging 0–9) including dairy consumption as harmful with a version including dairy items as protective. The beneficial impact of the Mediterranean diet tended to be stronger in men and was similar for all-cause, CVD and cancer mortality. Sensitivity analyses additionally including interaction variables of MDS with nationality and language region showed that the association of MDS with mortality was culturally independent (i.e. the interaction variable was not statistically significant, for details also see Online Resource Table S6 and S7). In contrast, sensitivity analyses including interaction variables of continuous MDS with sex showed that there was indeed statistically significant interaction by sex in the association between MDS and mortality (p interaction = 0.046, not shown).

Figure 1 shows HRs (basic and full adjustment) associated with categories of the MDS for all mortality causes by sex and for CVD and cancer for men and women combined. The lowest category of the MDS (MDS <4) served as reference (for details, see Online Resource Table S8). When comparing high versus low adherence to the Mediterranean diet in the fully adjusted model, men had a 20 % lower all-cause mortality risk (HR = 0.83, 95 % CI

Table 1 Baseline characteristics of 8,665 male and 9,196 female participants of NRP 1A, 1977–79 and Swiss MONICA study, 1983–92, 16–92 years at baseline

	Men	Women	All
N	8,665	9,196	17,861
Mean age in years (SD)	44.9 (13.3)	45.5 (13.9)	45.2 (13.6)
Person-years	179,210	203,493	382,703
Number of deaths			
All causes	2,179	1,774	3,935
Cardiovascular diseases (CVD)	751	634	1,385
Cancer	769	605	1,347
Marital status			
Single (%)	17.0	16.9	16.9
Married (%)	76.9	69.4	73.0
Widowed (%)	1.4	7.4	4.5
Divorced/separated (%)	4.8	6.4	5.6
Smoking status			
Never (%)	35.7	63.6	50.1
Former (%)	23.3	9.8	16.3
Light (%)	17.7	17.3	17.5
Heavy (%)	23.2	9.3	16.1
Body mass index (kg/m^2)			
Normal weight: BMI ≥18.5 or <25 (%)	44.5	60.8	52.9
Underweight: BMI <18.5 (%)	0.8	4.2	2.5
Overweight: BMI ≥25 or <30 (%)	43.7	25.6	34.3
Obesity: BMI ≥30 (%)	11.0	9.4	10.2
Nationality			
Swiss (%)	77.5	82.8	80.2
French, Italian, Spanish (%)	15.8	11.3	13.5
German, British, Austrian (%)	3.9	3.2	3.5
Other (%)	2.9	2.7	2.8
Region			
German-speaking Switzerland (%)	23.2	25.2	24.2
French-speaking Switzerland (%)	49.9	49.3	49.6
Italian-speaking Switzerland (%)	27.0	25.5	26.2
Dietary variables (consumption on the previous day)			
Salad (%)	69.90	71.88	70.92
Vegetables (%)	58.59	62.49	60.60
Fruits (%)	65.15	79.07	72.35
Dairy products (%)	87.63	88.81	88.24
Whole grains (%)	42.66	48.89	45.87
No red or processed meat (%)	22.83	30.92	27.00
Fish (%)	11.43	11.12	11.27
Monounsaturated lipids (%)	37.23	33.85	35.50
Alcohol (%)	56.47	34.36	45.07

NRP 1A National Research Programm 1A, *MONICA* MONItoring of trends and determinants in CArdiovscular disease, *SD* standard deviation, *CVD* cardiovascular diseases

Table 2 Adjusted hazard ratios (with 95 % confidence intervals) for mortality by cause of death, sex and consumption of selected food groups the previous day

	Men			Women			All		
	Basic model	Full model	Full model + mutually adjusted [HR (95 % CI)]	Basic model	Full model	Full model + mutually adjusted [HR (95 % CI)]	Basic model	Full model	Full model + mutually adjusted [HR (95 % CI)]
All cause									
Salad	0.92	0.95	0.93 (0.84–1.03)	0.95	0.97	0.96 (0.86–1.08)	0.93	0.96	0.94 (0.88–1.02)
Vegetables	0.96	1.00	0.99 (0.90–1.10)	1.00	1.02	1.00 (0.89–1.12)	0.97	1.00	0.99 (0.92–1.07)
Fruits	**0.80**	**0.85**	**0.87 (0.78–0.96)**	**0.85**	0.90	0.91 (0.80–1.04)	**0.81**	**0.87**	**0.88 (0.81–0.95)**
Dairy products[a]	**0.82**	0.88	0.89 (0.77–1.02)	**0.84**	0.91	0.92 (0.79–1.08)	**0.82**	**0.88**	**0.89 (0.80–0.99)**
Whole grains	0.92	0.95	0.96 (0.87–1.06)	0.95	0.97	0.96 (0.86–1.07)	0.93	0.96	0.96 (0.89–1.03)
No or white meat	1.01	1.01	1.03 (0.92–1.16)	0.99	0.98	0.95 (0.84–1.08)	0.99	0.99	0.99 (0.91–1.08)
Fish	0.96	0.96	0.98 (0.83–1.14)	1.16	1.16	1.13 (0.94–1.36)	1.03	1.04	1.03 (0.91–1.16)
Monounsaturated lipids[b]	**0.88**	**0.88**	**0.89 (0.80–0.98)**	0.97	0.98	1.02 (0.91–1.15)	**0.91**	**0.91**	0.94 (0.87–1.01)
Alcohol (wine)	1.03	0.99	1.04 (0.95–1.16)	1.03	1.02	1.05 (0.94–1.18)	1.03	1.01	1.05 (0.98–1.13)
Cardiovascular disease (CVD)									
Salad	1.03	1.07	1.04 (0.87–1.25)	0.98	0.97	0.93 (0.77–1.14)	1.00	1.03	0.99 (0.87–1.13)
Vegetables	0.95	1.01	1.00 (0.84–1.19)	1.00	1.04	1.10 (0.89–1.34)	0.97	1.02	1.03 (0.90–1.17)
Fruits	**0.83**	0.87	0.87 (0.73–1.04)	0.88	0.91	0.92 (0.73–1.15)	**0.84**	0.89	0.90 (0.78–1.03)
Dairy products[a]	0.89	0.95	0.90 (0.69–1.17)	0.96	1.03	1.05 (0.79–1.41)	0.91	0.96	0.94 (0.77–1.14)
Whole grains	1.16	1.21	1.17 (0.98–1.39)	1.04	1.02	0.93 (0.76–1.12)	1.10	1.12	1.07 (0.94–1.21)
No or white meat	1.00	0.99	1.03 (0.84–1.26)	1.06	1.05	1.00 (0.82–1.23)	1.02	1.01	1.01 (0.88–1.17)
Fish	0.80	0.82	0.88 (0.66–1.18)	1.19	1.23	1.21 (0.88–1.66)	0.93	0.97	1.00 (0.81–1.24)
Monounsaturated lipids[b]	**0.75**	**0.75**	**0.80 (0.66–0.95)**	0.88	0.92	0.96 (0.78–1.19)	**0.79**	**0.80**	**0.85 (0.74–0.97)**
Alcohol (wine)	0.89	**0.85**	0.90 (0.76–1.07)	0.88	0.92	1.03 (0.85–1.24)	**0.89**	**0.89**	0.97 (0.85–1.10)
Cancer									
Salad	0.87	0.91	0.90 (0.76–1.06)	0.97	0.99	1.02 (0.84–1.24)	0.92	0.94	0.95 (0.83–1.08)
Vegetables	0.91	0.95	0.95 (0.81–1.12)	0.89	0.91	0.86 (0.71–1.04)	0.90	0.93	0.91 (0.80–1.03)
Fruits	**0.76**	**0.80**	**0.82 (0.70–0.97)**	**0.76**	**0.81**	0.83 (0.67–1.02)	**0.76**	**0.81**	**0.83 (0.73–0.95)**
Dairy products[a]	**0.78**	0.83	0.81 (0.65–1.02)	0.88	0.95	0.97 (0.74–1.28)	**0.83**	0.88	0.88 (0.74–1.05)
Whole grains	**0.84**	0.88	0.88 (0.75–1.05)	0.95	1.00	1.05 (0.87–1.27)	**0.88**	0.92	0.95 (0.84–1.07)
No or white meat	1.03	1.06	1.09 (0.90–1.31)	**0.80**	**0.80**	**0.76 (0.62–0.94)**	0.92	0.93	0.93 (0.81–1.07)
Fish	1.00	0.99	0.95 (0.73–1.23)	1.10	1.10	1.08 (0.79–1.47)	1.04	1.04	1.00 (0.82–1.23)
Monounsaturated lipids[b]	0.88	0.85	0.85 (0.72–1.01)	1.10	1.08	1.11 (0.92–1.35)	0.97	0.95	0.96 (0.85–1.09)
Alcohol (wine)	1.17	1.10	1.17 (0.99–1.39)	1.22	1.20	1.14 (0.95–1.38)	1.20	1.16	1.17 (1.04–1.33)

Reference salad, vegetables, fruits, dairy, whole grains, fish, monounsaturated lipids, alcohol (wine): no consumption of selected food group the previous day; Reference no or white meat: consumption of red or processed meat the previous day

[a] Dairy products included milk, milkdrink, skim milk, yogurt and cheese

[b] Monounsaturated lipids included olive, groundnut or canola oil used for preparation of warm or cold meals; basic model: adjusted for age, sex and survey wave; full model: additionally adjusted for marital status, smoking, BMI, region and nationality; statistically significant results ($p < 0.05$) in bold; population sample: 8,665 male participants and 9,196 female participants of NRP 1A, 1977–1979 and Swiss MONICA study, 1983–1992, 16–92 years at baseline

0.73–0.94). The figures for men and both sexes suggest some kind of "dose dependence" between degree of adherence to the Mediterranean diet and risk of dying. In women, effects were generally less pronounced.

The association of consumption of dairy products with mortality is shown in Table 4, with no consumption of dairy products the previous day as reference. The effects tended to be stronger for cancer than for CVD, for low-fat than for

Table 3 Adjusted hazard ratios (with 95 % confidence intervals) for mortality by cause of death, sex and classical MDS (continuous) with dairy products as harmful and alternative MDS (continuous) with dairy products as protective

	Men HR[a] (95 % CI)	Women HR[a] (95 % CI)	All HR[a] (95 % CI)
Classical MDS with dairy products as harmful			
All cause			
Basic model	**0.95 (0.92–0.98)**	0.99 (0.96–1.03)	**0.96 (0.94–0.99)**
Full model	**0.96 (0.93–0.99)**	1.00 (0.97–1.04)	0.97 (0.95–1.00)
Cardiovascular disease (CVD)			
Basic model	**0.93 (0.89–0.99)**	0.97 (0.91–1.02)	**0.94 (0.91–0.98)**
Full model	0.95 (0.90–1.00)	0.98 (0.92–1.04)	0.96 (0.92–1.00)
Cancer			
Basic model	**0.93 (0.89–0.98)**	0.99 (0.93–1.05)	0.96 (0.92–1.00)
Full model	**0.94 (0.89–0.99)**	1.00 (0.94–1.06)	0.97 (0.93–1.01)
Alternative MDS with dairy products as protective			
All cause			
Basic model	**0.93 (0.90–0.96)**	0.97 (0.94–1.00)	**0.94 (0.92–0.96)**
Full model	**0.94 (0.92–0.97)**	0.98 (0.95–1.02)	**0.96 (0.94–0.98)**
Cardiovascular disease (CVD)			
Basic model	**0.93 (0.88–0.98)**	0.96 (0.91–1.02)	**0.94 (0.90–0.97)**
Full model	0.95 (0.90–1.00)	0.98 (0.92–1.04)	**0.96 (0.92–0.99)**
Cancer			
Basic model	**0.91 (0.87–0.96)**	0.97 (0.91–1.02)	**0.94 (0.90–0.98)**
Full model	**0.92 (0.88–0.97)**	0.98 (0.93–1.04)	**0.95 (0.92–0.99)**

[a] Per one-point increase in MDS; basic model: adjusted for age, sex and survey wave; full model: additionally adjusted for marital status, smoking, BMI, region and nationality; statistically significant results ($p < 0.05$) in bold; population sample: 8,665 male participants and 9,196 female participants of NRP 1A, 1977–1979 and Swiss MONICA study, 1983–1992, 16–92 years at baseline

whole milk dairy products, and for men compared with women.

Discussion

In this general population sample, which included all three major language regions of Switzerland, we observed an inverse association between adherence to a Mediterranean diet pattern and mortality, which was largely independent of cultural background (language region and nationality). Because of the rough estimation of dietary intake, i.e. recall of food consumption on the previous day, and the unexpected impact of dairy food consumption in Switzerland (protective rather than deleterious), we developed a modified version of the MDS. Nevertheless, scoring high in the MDS was associated with lower CVD and cancer mortality also after adjustment for major confounders. Adherence to Mediterranean diet generally had a stronger impact on mortality reduction in men than in women.

Mediterranean diet and health

Our results corroborate previous findings on the impact of Mediterranean diet on health [13, 14]. In line with other authors, even moderate adherence to a Mediterranean diet pattern was significantly inversely associated with mortality [3, 6, 29, 30], although the full impact was seen at maximum adherence. In our analyses, we relied on an adapted score compared to that of Trichopoulou et al. [26]. The main difference was that we classified the consumption of dairy products as favourable and not as deleterious. Consumption of dairy products was consistently associated with lower cancer and all-cause mortality. In Switzerland, production and consumption of dairy products have a long tradition and there is a strong cultural affinity to them, which is uncommon in Mediterranean countries. There have been previous efforts to culturally adapt the original MDS [1, 26] in order to appropriately take into account the diets of Mediterranean versus non-Mediterranean populations [6, 10, 31–33].

Besides dairy products, only fruits and items rich in monounsaturated fatty acids reached statistical significance among the single MDS components. A significant impact of single MDS components is often not apparent. However, when using the single components jointly in form of a MDS, the inverse association with fatal or non-fatal outcomes becomes clearly visible [3, 6, 26, 29, 30]. This underlines the concept that the beneficial effect of the Mediterranean diet occurs through the general pattern and the interaction of its various components instead of depending on isolated items of the Mediterranean diet [8, 29, 34, 35]. Interestingly, despite the coarse dietary assessment, alcohol consumption showed the expected pattern with a decrease in CVD mortality and an increase in cancer mortality [36].

In the present findings, the potentially protective impact of the Mediterranean diet was more apparent for men than for women. Previous studies showed conflicting results: Some showed a more pronounced effect in women [9, 30], others in men [8], and some studies showed even similar results in both sexes [3, 5] or did not analyse men and women separately [1, 2, 6, 7, 10].

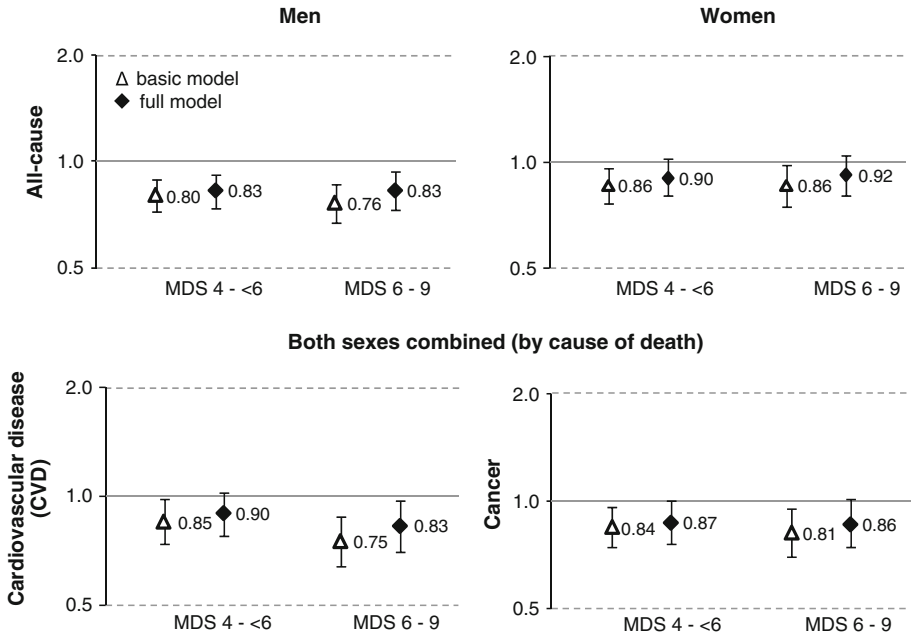

Fig. 1 Adjusted hazard ratios (with 95 % confidence intervals) for mortality by cause of death, sex and MDS category (with dairy products as protective and reference: MDS <4). Basic model: adjusted for age, sex and survey wave; full model: additionally adjusted for marital status, smoking, BMI, region and nationality; population sample: 8,665 male participants and 9,196 female participants of NRP 1A, 1977–1979 and Swiss MONICA study, 1983–1992, 16–92 years at baseline

Impact of cultural background

Recent studies suggested that the Mediterranean diet has as stronger protective effect in populations living in Mediterranean countries compared to those in other European countries [7, 18]. However, our results show that the association between the Mediterranean diet and mortality was largely independent of cultural background. Another recent study comparing mortality differences between the German- and French-speaking part of Switzerland as well as between Germany and France illustrated that mortality dissimilarities were larger between these countries than between the respective Swiss regions [37]. Therefore, international variations in mortality might not just be influenced by Mediterranean diet patterns may but also relate to peculiarities in national assignment of cause of death, in self-reporting of diet or in national variations in gathering, processing and interpretation of data.

However, the impact of diet on health may depend on various factors, and this interaction may change over time. The relationship between environment, society agriculture, and marketing is complex and subject to a fundamental change in the past decades. Whereas prior to the modern era populations have consumed mostly what has been produced locally, the availability and diversity of foods and beverages have led to a "globalization" of eating habits with potential influence on their association with health outcomes [38].

Dairy food: Is there a Swiss alpine paradox?

In the traditional MDS concept, dairy products are considered as a detrimental component [2, 3, 13, 18, 35]. Dairy products increase the intake of saturated fatty acids which may increase the risk of CVD [39, 40]. We can only speculate why this was not supported by our Swiss sample. Compared to cheese from other countries, Swiss cheese—in particular cheeses produced from milk of purely grass-fed alpine cows—has a special fatty acid profile. Swiss cheese and other dairy products are high in n-3 fatty acids, but comparably low in saturated fats and arachidonic acid [19, 41–43]. This could explain why we found an inverse and not a positive association with CVD mortality [44, 45]. In contrast to Mediterranean countries, dairy products are consumed on a daily basis by a large proportion of the Swiss population. A systematic review showed a modest inverse association of dairy food intake with CVD [46]. Another review suggested a protective effect of consumption of milk and dairy products on some types of cancer with a stronger effect of low-fat products [40, 47, 48]. This is supported by our findings.

The Mediterranean diet is a construct based on foods traditionally eaten in Mediterranean countries. Thus, the focus lies on foods that are locally established for centuries, and this may be the key element determining health properties [49]. Most countries around the world have their own traditional local foods that are potentially health promoting [49, 50]. In Switzerland, this could be dairy products. Possibly, an adaptation of the Mediterranean diet to local characteristics could help differentiating healthy and unhealthy dietary patterns more specifically instead of entirely relying on a concept which is partially "imported" from other cultures.

Limitations

Dietary intake and covariates were only assessed at study entry and not repeatedly during follow-up. Therefore,

Table 4 Adjusted hazard ratios (with 95 % confidence intervals) for mortality by cause of death, sex and consumption of dairy products the previous day

	Men HR (95 % CI)	Women HR (95 % CI)	All HR (95 % CI)
All cause			
Basic model			
All dairy products	**0.82 (0.72–0.93)**	**0.84 (0.73–0.97)**	**0.82 (0.75–0.91)**
Whole milk dairy products	**0.84 (0.74–0.96)**	**0.85 (0.73–0.98)**	**0.84 (0.76–0.92)**
Low-fat dairy products	**0.77 (0.66–0.89)**	**0.81 (0.70–0.95)**	**0.78 (0.70–0.87)**
Full model			
All dairy products	0.88 (0.77–1.00)	0.91 (0.79–1.04)	**0.88 (0.80–0.96)**
Whole milk dairy products	0.90 (0.78–1.02)	0.90 (0.78–1.04)	**0.89 (0.80–0.98)**
Low-fat dairy products	**0.82 (0.71–0.96)**	0.90 (0.76–1.05)	**0.84 (0.76–0.94)**
Cardiovascular disease (CVD)			
Basic model			
All dairy products	0.89 (0.71–1.13)	0.96 (0.76–1.23)	0.91 (0.77–1.08)
Whole milk dairy products	0.87 (0.69–1.11)	0.97 (0.75–1.25)	0.90 (0.76–1.07)
Low-fat dairy products	0.92 (0.71–1.20)	0.93 (0.70–1.22)	0.91 (0.75–1.09)
Full model			
All dairy products	0.95 (0.75–1.20)	1.03 (0.80–1.32)	0.96 (0.81–1.13)
Whole milk dairy products	0.93 (0.73–1.19)	1.02 (0.79–1.32)	0.95 (0.79–1.23)
Low-fat dairy products	0.99 (0.76–1.29)	1.01 (0.77–1.34)	0.97 (0.80–1.17)
Cancer			
Basic model			
All dairy products	**0.78 (0.63–0.96)**	0.88 (0.69–1.13)	**0.83 (0.71–0.97)**
Whole milk dairy products	0.82 (0.66–1.02)	0.92 (0.72–1.19)	0.87 (0.74–1.02)
Low-fat dairy products	**0.67 (0.52–0.86)**	0.77 (0.58–1.02)	**0.72 (0.60–0.87)**
Full model			
All dairy products	0.83 (0.67–1.03)	0.95 (0.74–1.21)	0.88 (0.75–1.04)
Whole milk dairy products	0.87 (0.70–1.08)	0.98 (0.76–1.27)	0.92 (0.78–1.08)
Low-fat dairy products	**0.71 (0.55–0.92)**	0.84 (0.63–1.11)	**0.77 (0.64–0.93)**

Dairy products: whole milk and low-fat products; reference: no consumption of dairy products the previous day; basic model: adjusted for age, sex and survey wave; full model: additionally adjusted for marital status, smoking, BMI, region and nationality; statistically significant results ($p < 0.05$) in bold; population sample: 8,665 male participants and 9,196 female participants of NRP 1A, 1977–1979 and Swiss MONICA study, 1983–1992, 16–92 years at baseline

later changes in diet could not be considered, and estimates of associations between dietary patterns and mortality risk might be biased. Moreover, food items were assessed in a coarse way, and no information on the amount consumed was available. To the best of our knowledge, the questionnaire has not been validated as its intention was to be used as a rough screener for a healthy diet.

Participants of the included studies were presumably more healthy and health conscious than the general population, again limiting the span between extreme behaviours and, thus, the magnitude of estimates [23]. Finally, we only had information on fatal outcomes and could not examine the association of MDS with cancer and CVD incidence. It is important to note that quite a large number of different models for distinct types of death were fitted for this paper. Therefore, the issue of multiple testing cannot be ignored, and all significant results should be interpreted with caution. As we have conducted several sub-analyses, we cannot exclude that some of our findings might be due to chance.

Conclusion

In Switzerland, adherence to a Mediterranean diet pattern, assessed with a simplified 24-h recall check-list, was associated with lower CVD and cancer mortality. The association was mainly due to the effect in men and was largely independent of cultural background. The fact that we found evidence for a beneficial rather than a deleterious effect of dairy food consumption suggests that reconsidering an adaptation of the traditional Mediterranean diet concept in non-Mediterranean countries could be worthwhile, especially when taking into account country-specific traditional foods. However, our crude dietary assessment method calls for a validation with more accurate method.

Acknowledgments The authors thank the Swiss Federal Statistical Office for providing mortality and census data and for the support which made the Swiss National Cohort and this study possible. The members of the Swiss National Cohort Study Group are Milo Puhan (Chairman of Scientific Board), Matthias Bopp (both Zurich), Matthias Egger (Chairman of Executive Board), Adrian Spoerri, Marcel Zwahlen (all Bern), Nino Künzli (Basel), Fred Paccaud (Lausanne) and Michel Oris (Geneva). This work was supported by the Swiss National Science Foundation (Grants 3347CO-108806 and 33CS30-134273).

Conflict of interest The authors declare that they have no conflict of interest.

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